International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD)
ISSN (P): 2249–6866; ISSN (E): 2249–7978
Vol. 12, Issue 1, Jun 2022, 63–68

PARAMETRIC STUDIES OF VOIDED R.C.C. SLAB FOR DIFFERENT FORMS OF CUTOUTS

DR. VIKASGANDHE

Structural Engineering Indore, Madhya Pradesh, India

ABSTRACT

The design of solid R C C concrete slab in construction, was a traditional activity. Because of solid slab, the quantity of concrete was quite high and there by the slab was uneconomical. To reduce the quantity of concrete, without affecting the strength, voids were created in a slab. This concept of creating the voids, was done not only to reduce the quantity of concrete but also to make the structure environment friendly. In addition to this, it was important to see that such structure should also satisfy all the required checks mentioned in IS Code 456-2000. Checks includes flexural strength, shear strength, deflection etc. It was observed that the duction of concrete quantity varies from20 %to50 %, depending on various factors like forms, shapes, center to center spacing of voids. This reduction of concrete is beneficial in terms of financial savings and building performance too. This paper has dealt with the design of two-way R C C solid slab as well as voided slab with different variable parameters but keeping the aspect ratio as one i.e. L/B=1. To investigate the reduction in concrete quantity, these two types of slabs were designed for different over all thickness, varying from 250mm to 150mm. Regarding the voids in the selected two-way R C C slabs, different forms and shapes of voids were provided. Selected shapes and forms of voids were square, circular, elliptical, frustum of cone and dome shape. The area, height and center to center spacing between the voids were suitably selected as per design considerations. The designs of all the selected parameters of solid and the voided two-way R C C slabs, were considered with due permutations and combinations, for the cost- effective optimization. All the results thus obtained were shown in a tabular form indicating percentages of concrete as compared with R C C solid slab.

KEYWORDS :Concrete, Flexure, Neutral axis, Punching Stress, Reinforcement

Received: May 11, 2022; **Accepted**: Jun 01, 2022; **Published**: Jun 11, 2022; **Paper Id**: IJCSEIERDJUN20228

Original Article

INTRODUCTION

In building construction, the consumption of concrete was maximum as compared with other concrete components. The concrete members comprise of slab, beam, column and footing. It was observed that quantity of concrete of slab is about 40 % of total quantity of other concrete members as mentioned above. With the cost of concrete increasing over the period of time, it felt necessary to reduce the quantity of concrete in slab to achieve economy.

It was a well-known fact that, concrete bears the compression while steel resists the tension in concrete members. Maximum magnitude of compression and tension in any concrete section, were at the extreme fibers. The depth of actual neutral axis was measured from the top of compression zone. With this concept of neutral axis, voids were proposed in tension zone area. To save the concrete, replace the concrete from tension zone as concrete did not bear the tension. The spacing of openings were adjusted in such a manner, that the depth of actual neutral axis should be above the height of openings. The saving of concrete was based on various parameters related to size, shape, height and center to center spacing of voids (openings). To create the voids, as per requirements, following systems were adopted*Bubble Deck, *Cobiax, *U – Boot Section, *Bee – Plate system. Paper dealt with

following forms and shapes of openings to predict quantity of saving of concrete in a selected concrete slab. From the results it was observed that the saving in concrete voided slab as compared to solid concrete slab with same aspect ratio, varies from20 % to 50 %.

Solid concrete slab and voided concrete with same aspect ratio were designed and checked for flexure and shear stress as per guidelines of IS Code 456 -2000.The shear strength of voided concrete slab depends upon effective mass of concrete. To avoid the failure of slab due to punching shear, the voids around the column areas were avoided. It was also observed that deflection of voided slab was 5 % to 6 % more than solid concretes lab. This additional deflection of voided slab was kept well within the permissible limits by changing various parameters. Paper dealt with two-way concrete solid and voided slabs with three different slab thicknesses and keeping the aspect ratio as one only. Analysis and design was carried out for L/Bas*3 M X 3 M, respectively. Other selected parameters were forms of voids (openings).Following five different forms and shapes were considered *Square, * Cylindrical, *Elliptical, *Frustum of cone, and * Dome shape See figure 1.

Square Cylinder Frustum of cone Elliptical Dome

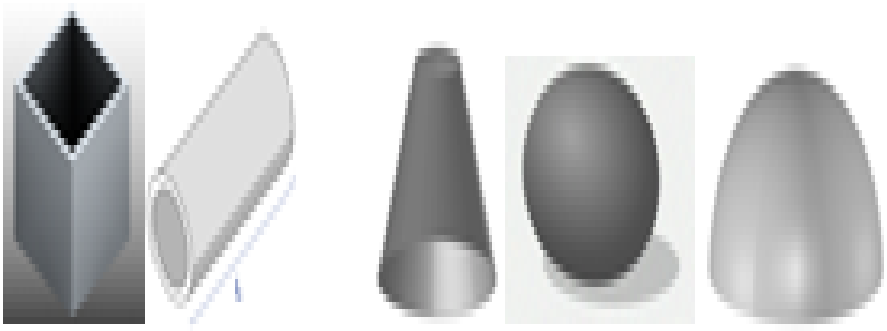

Figure 1: Five Forms of Voids Selected For Analysis of Slab

Other important variable parameters were spacing of voids and height of openings. To design the structure for cost effective measures, different center to center spacing of openings were considered. For the considerations of optimizations, three over all thickness of concrete were also adopted to achieve appropriate results. The results thus obtained were compared with solid concrete slab. All the results thus obtained were shown in a tabular form. Plan and sections of voided slab, before casting of slab has been shown in Figure2.

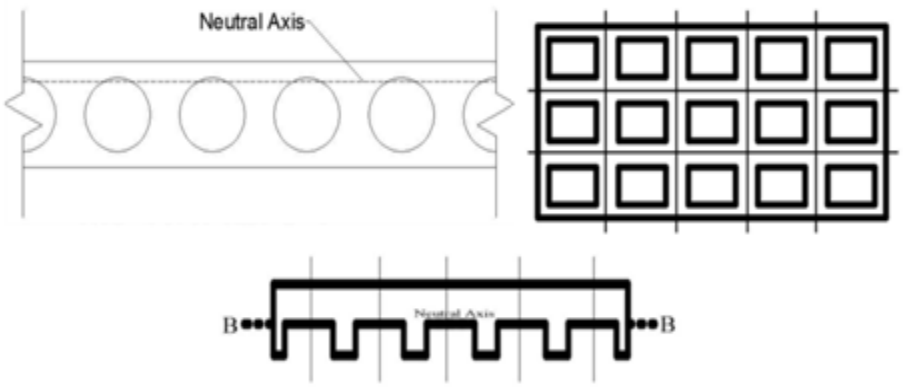

Figure 2: Plan and Two sections of slab

METHODOLOGY

Process is dealt to achieve the percentage saving of concrete by creating voided slab as compared with concrete solid slab for the same span and same over all thickness. In this regard, computer program in terms of excel spread sheet was prepared, using required parameters. Analysis and design of both the slabs, solid and voided slab, was carried out using Limit State Method, considering M-20and Fe-415. As per requirements, IS Cods 456-2000 was referred. Aspect ratio of both these concrete slabs was always taken as one. The length of panel slabs of 3.0X3.0m, were selected. Overall thicknesses of slabs were taken as250 mm, 200mm and 150mm respectively. To assess the maximum percentage of saving of voided slab, five different types form sand shapes of cutout/openings were taken as*Square*Cylindrical*Elliptical*Frustum of cone and *Dome shape. Other variable parameters were*size of openings, *height of openings, *center to center spacing between each voided hole* Total number of voided openings in complete panel length of slab were also incorporated and shown in observation tables. Considering first case, slab thickness = 250mm then substituting there quire parameters for all five shapes of cutout holes{as per the table shown in observation).After completion of result calculations of table 1, consider second case in which the slab thickness = 200 mm and complete the second case. In the third case, selecting the overall slab thickness as 150mm{Already shown in table no. 3), complete the calculation and enter the results thus obtained in Case 3.

The clear cover to steel reinforcement was kept as 20mm. The diameter of steel bar was selected as per design requirements. Generally, 20mm, 16mm, 12mm diameters of bars were considered as per design requirements. T beam section was designed, keeping the width of web as 100mm constant through out the calculations to achieve the maximum saving in concrete due to voided slab. The height of opening was considered on the basis of depth of actual neutral axis from the top of compression zone. The total volume of solid slab and total volume of openings were calculated and there by percentage saving in concrete was obtained each and every case, mentioned above. After making all the permutation sand combinations of given data, only the final outcome was displayed in a tabular form. The slab was bifurcated into number of T beam. The T beam was analyzed and designed using Limit State Method as per IS Code 456-2000.

Two-way concrete voided slab was designed and compared the results for saving of concrete with solid concrete slab with opening (voids) was adjusted by varying the flange width, width of web, reinforcements in tension zone, so that depth of actual neutral axis from the top of compression zone, did not overlap with height of the cutout.

OBSERVATIONS

The results obtained by comparing the saving of concrete in terms of percentage**,** for voided concrete slab with solid concrete slab of panel length of 3.0 X 3.0 m. For detailed study, five different forms and shapes of cut-outs in voided slab were considered. Three cases were studied in all three cases, slab panel length of 3.0 X 3.0m were taken. Five forms of openings, selected, were Square, cylindrical, elliptical, frustum of cone and hemispherical dome. In case1, the overall depth of slab was taken as 250 mm. In case 2 the overall depth of slab was seduced to 200 mm and in case 3, the thickness of slab was still reduced and taken as 150mm. Outcome of the conclusion has been mentioned below.

Case 1: **Panel size =3.0X3.0m, Depth of slab=250mm**

Table 1: Showing Percentage Saving of Concrete for Different Voids

Description	Square	Cylindrical	Cone frustum	Ellipse	Dome
Size in mm	400 X 400	Diameter=400	D1=500 D2=250	A=300B=270	D=400
Areamm^2	160000	125664		63605.25	62820
Height mm	200	200	200	200	200
Spacing mm	100	100	100	100	100
Total voids	36	36	25	49	36
Saving in %	51.27 %	40.21 %	25.20%	27.7 %	26.83%

Case 2: Panel size =3.0 X3.0m, Depth of slab=200mm

Table 2: Showing Percentage Saving of Concrete for Different Voids

Description	Square	Cylindrical	Cone Frustum	Ellipse	Dome
Size in mm	400 X 400	Diameter=400	D1=400D2=300	A=300B=270	D=240
Areamm^2	160000	125664		63605.25	
Height mm	150	150	150mm	200	120 mm
Spacing mm	100	100	100 mm	100	100
Total voids	36	36	36	49	81
Saving in %	48.0%	37.70%	28.76%	27.7 %	16.28%

Case 3: Panel size =3.0 X3.0m, Depth of slab=150mm

Table 3: Showing Percentage Saving of Concrete for Different Voids

Description	Square	Cylindrical	Cone Frustum	Ellipse	Dome
Size in mm	400 X 400	Diameter=400	D1=400D2=300	A=400B=360	D=200
Areamm^2	160000	125664	122911.8	113076	10012.56
Height mm	100	100	100mm	100	100
Spacing mm	100	100	100 mm	100	100
Total voids	36	36	36	36	100
Saving in %	42.66%	44.67%	25.56%	30.15%	15.51 %

RESULTS

- It was concluded that as the thickness of slab reduces, the saving percentage of concrete also decreases.
- To resist the punching shear failure around the column, either provide the drop slab of required thickness or provide additional shear reinforcement around the column.
- All the required checks were applied, during the design of voided slab and it was observed that all the parameters were well within the limit of accuracy.
- It was observed that in all the three cases and five forms of types of openings, the percentage of saving of concrete was minimum in case of dome shape of opening as compared with other four selected forms of cutouts.
- Similarly, it was concluded that maximum percentage of saving of concrete in voided slab was observed in square form of opening as compared to other selected forms of openings.
- It was observed that bending stress of voided slab was about 6.4 % less as compared to solid concrete slab of

same aspect ratio and over all slab thickness but still obtained results were well within the limits of accuracy.

- Deflection of voided concrete slab was observed to be about 6.0 % more as compared with concrete solid slab with same parameters and same aspect ratio but it is well within the limits of accuracy.

REFERENCES

1. *Vaignan. B, Prasad, B. SRK, "Analysis of voided deck slab and cellular deckslab using Midas Civil ", "International Journal of engineering research and technology", Vol 03, Issue09Sept2014, pp. 1 2 7 7 - 12 8 9.*
2. *Shikha. S, Nishant R., "Experimental study on Bubble deck slab", "International research journal of engineering and technology", Vol 04, Issue05May 2017, pp 1000 – 1004.*
3. *Neeraj T. and Sana Z., "Structural behavior of bubble deck slab and its application", "International journal for scientific research and development", Vol 04, Issue 02, 2016.*
4. *Bhagyashri, G, and Barelikar, S., "An experimental study on two-way bubble deck slab with spherical hollow balls", "International Journal of Recent scientific research", Vol07, Issue06, 2016.,pp.11621 – 11626*
5. *ArtiS, and Nagesh H., "An experimental study on bubble deck slab system with elliptical balls", "Proceeding of NCRTE and Indian journal of Science and research" 2015.*
6. *Vardha Raj A. and Fazil P., "Analysis on performance of Reinforced concrete and prestressed slabs using balls and cores". A literature review in "International research journal of engineering and technology", Vol05, Issue.12 Dec. 2018. pp.430 – 433.*
7. *Mundhada, Ashok R., and Arun D. Pophale. "Effect of elevated temperatures on performance of RCC beams." International Journal of Civil, Structural, Environmental and Infrastructure, Engineering Research and Development 3.3 (2013): 105-112.*
8. *Piplewar, SURESH B., NARENDRA M. Kanhe, and D. E. V. E. N. D. R. A. Pandey. "Impact of curing on strength of concrete." International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD) 4.2 (2014): 119-126.*
9. *Ye, Yousif Jabbar Lafta1&Kun. "Structural Behavior Of Deep Reinforced Concrete Beams Under Indirect Loading Condition." International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD) 5. 4, Aug 2015, 53 72.*
10. *Mundhada, Ashok R., and Arun D. Pophale. "Effect of elevated temperatures on performance of RCC beams." International Journal of Civil, Structural, Environmental and Infrastructure, Engineering Research and Development 3.3 (2013): 105-112.*